

S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

Be it known that we, Michael J. Grier a citizen of the United States, residing at 18215 159th Avenue NE, Woodinville, Washington 98072, RoseMarie FitzSimons, a citizen of Ireland, residing at 408 N 39th Street, Seattle, Washington 98103, David D'Souza, a citizen of the United States, residing at 7201 Holly Hill Drive, Mercer Island, Washington 98040, Peter Wilson a citizen of Great Britain, residing at 1517 1st Street, Kirkland, Washington 98033, Srivatsan Parthasarathy, a citizen of India, residing at 17745 SE 58th Place, Bellevue, Washington 98006, Sanjay G. Shenoy, a citizen of India, residing at 9336 132nd Avenue NE, Redmond, Washington 98052 and Micheal Dunn, a citizen of the United States, residing at 6355 137th Ave NE #297, Redmond, Washington 98052 have invented a certain new and useful **Isolating Assembly Versions For Binding To Application Programs** of which the following is a specification.

ISOLATING ASSEMBLY VERSIONS FOR BINDING  
TO APPLICATION PROGRAMS

CROSS-REFERENCE TO RELATED APPLICATIONS

5 The present application claims priority to United States  
Provisional Patent Application Serial No. 60/199,374, filed  
April 24, 2000, and is also related to copending United States  
Patent Application entitled "Configurations for Binding  
*Software Assemblies to Applications,*" filed concurrently  
10 herewith.

FIELD OF THE INVENTION

The present invention is generally directed to computer  
systems, and more particularly to executable computer code such  
15 as application programs that utilize shared assemblies  
(components).

BACKGROUND OF THE INVENTION

At one time, computer applications were monolithic blocks  
20 of executable code and data, although some of their data such  
as variable settings could be maintained in separate files.  
This made tasks like moving or replacing the application  
simple. In contrast, contemporary computer applications and  
other executable code (such as an operating system component)  
25 bind to and make use of shared components, wherein in general a  
component is a self-contained software entity, offering a set

of functions that can be used by a variety of applications.

Such components include dynamic link libraries (DLLs) and objects such as OLE (Object Linking and Embedding) components and COM (Component Object Model) components, including ActiveX® controls. In turn, some of these shared components depend on other shared components.

On any given machine, at present there is one version of each of these components shared by applications, such as the most-recently installed version, although some mechanisms are known that replace an installed component only when an available replacement component has a higher version number.

The metadata maintained for using these components is generally maintained in the system registry, and the application has the names of the needed components compiled into its binary code.

Because in general the application does not change as components change, to function properly, global component sharing requires that any shared component function exactly like previous other versions of that component with respect to what an application expects. In practice, however, perfect backwards compatibility is difficult if not impossible to achieve, among other reasons because it is impractical to test the many configurations in which the shared component may be used. For example, both newer and older applications end up sharing the same component, whereby over time, fixing and improving the component becomes increasingly difficult.

Moreover, the practical functionality of a component is not easily defined. For example, some applications may utilize unintended side effects in a component that are not considered part of the core function of the component, e.g., an application may become dependent on a bug in a component, and when the component publisher chooses to fix that bug, the application fails. Of course, on the other side, application writers cannot test future versions of components.

As a result, problems occur when a component is updated to its newer version, such as when a new application or operating system service pack is installed with updated copies of components, as the newly installed component versions become the ones used by other applications and components on the system. The sheer volume of applications and components that rely on other components magnifies this problem, which is sometimes referred to as "DLL Hell."

One mechanism that provided sharing for some applications while enhancing the stability of other applications was provided in Microsoft Corporation's Windows® 2000 and Windows® 98, Second Edition, operating systems. In general, this mechanism provided a way for an application to be bound to a local copy of a component instead of a shared copy. However, with this solution, a component needed to be isolated per application, which resulted in multiple copies of the same component version having to be maintained on the system.

Additionally global non-code data, such as COM data, was not isolated, limiting this mechanism's usefulness with COM objects.

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#### SUMMARY OF THE INVENTION

Briefly, the present invention provides a method, system and infrastructure that allow an application to run with specified versions of components bound thereto, wherein each component (also referred to herein as an assembly, wherein an assembly is set of one or more component files which are versioned and ship as a unit) may exist and run side-by-side on the system with other versions of the same assembly being used by other applications. To this end, the application provides a manifest to specify any desired assembly versions. An activation context is created for the application based on the manifest to map global, version independent names to a particular version maintained in an assembly cache or in the application's respective directory. In order to specify a version for an assembly, applications need not have their code rewritten, but instead can provide the application manifest, (e.g., in an XML data structure). Similarly, each assembly has an assembly manifest that specifies the versions of dependent assemblies.

In the pre-application execution phase when creating a new process, the operating system checks for an application

manifest in same file system directory as the calling executable. When an application manifest exists, the operating system checks for an activation context for the application that was built from the manifest. If the activation context 5 does not exist (for example this is the first time application has been executed), or it exists but is not coherent with current policy, an activation context is created via the application manifest and the assembly manifests of any dependent assemblies / assemblies listed in the application 10 manifest.

At runtime, when a program requests creation of a global object, the operating system automatically consults the activation context built from the application and assembly manifests, to locate and load the assembly version that the 15 application wants to use. The operating system also maps any uses of this named object (such as object (e.g., Windows<sup>®</sup>) classes) to the appropriate version to allow for multiple versions of the code module to run simultaneously without interfering with each other. By its manifest and the 20 activation context built therefrom, an application may be bound to specific assembly versions and thereby be isolated from changes made to assembly versions by other applications.

Other objects and advantages will become apparent from the following detailed description when taken in conjunction with 25 the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram representing a computer system into which the present invention may be incorporated;

5 FIG. 2 is a block diagram generally representing applications and other components, including manifests that are used to specify assembly versions, in accordance with an aspect of the present invention;

FIG. 3 is a block diagram generally representing various 10 components for initializing an activation context to map version-independent assembly names to version-specific assemblies for an application in accordance with an aspect of the present invention;

FIG. 4 is an example of information maintained within an 15 activation context in accordance with an aspect of the present invention;

FIG. 5 is a block diagram generally representing various components for utilizing an activation context at runtime to locate and load a particular version of a requested assembly 20 version in accordance with an aspect of the present invention;

FIGS. 6 and 7 comprise a flow diagram representing general steps taken to initialize an activation context in accordance with an aspect of the present invention;

FIG. 8 is a representation of a dependency graph useful in constructing the activation context in accordance with an aspect of the present invention; and

FIG. 9 is a flow diagram representing general steps taken 5 to utilize an activation context during runtime in accordance with an aspect of the present invention.

#### DETAILED DESCRIPTION

##### EXEMPLARY OPERATING ENVIRONMENT

10 FIGURE 1 illustrates an example of a suitable computing system environment 100 on which the invention may be implemented. The computing system environment 100 is only one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or 15 functionality of the invention. Neither should the computing environment 100 be interpreted as having any dependency or requirement relating to any one or combination of components illustrated in the exemplary operating environment 100.

The invention is operational with numerous other general 20 purpose or special purpose computing system environments or configurations. Examples of well known computing systems, environments, and/or configurations that may be suitable for use with the invention include, but are not limited to, personal computers, server computers, hand-held or laptop 25 devices, multiprocessor systems, microprocessor-based systems,

set top boxes, programmable consumer electronics, network PCs, minicomputers, mainframe computers, distributed computing environments that include any of the above systems or devices, and the like.

5        The invention may be described in the general context of computer-executable instructions, such as program modules, being executed by a computer. Generally, program modules include routines, programs, objects, components, data structures, and so forth, that perform particular tasks or

10      10 implement particular abstract data types. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both

15      15 local and remote computer storage media including memory storage devices.

With reference to FIG. 1, an exemplary system for implementing the invention includes a general purpose computing device in the form of a computer 110. Components of the

20      20 computer 110 may include, but are not limited to, a processing unit 120, a system memory 130, and a system bus 121 that couples various system components including the system memory to the processing unit 120. The system bus 121 may be any of several types of bus structures including a memory bus or

25      25 memory controller, a peripheral bus, and a local bus using any

of a variety of bus architectures. By way of example, and not limitation, such architectures include Industry Standard Architecture (ISA) bus, Micro Channel Architecture (MCA) bus, Enhanced ISA (EISA) bus, Video Electronics Standards

5 Association (VESA) local bus, and Peripheral Component Interconnect (PCI) bus also known as Mezzanine bus.

The computer 110 typically includes a variety of computer-readable media. Computer-readable media can be any available media that can be accessed by the computer 110 and includes

10 both volatile and nonvolatile media, and removable and non-removable media. By way of example, and not limitation,

computer-readable media may comprise computer storage media and communication media. Computer storage media includes both volatile and nonvolatile, removable and non-removable media

15 implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile

20 disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computer 110.

Communication media typically embodies computer-readable

25 instructions, data structures, program modules or other data in

a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a 5 manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of the any of the above should 10 also be included within the scope of computer-readable media.

The system memory 130 includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) 131 and random access memory (RAM) 132. A basic input/output system 133 (BIOS), containing the basic 15 routines that help to transfer information between elements within computer 110, such as during start-up, is typically stored in ROM 131. RAM 132 typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by processing unit 120. By way of 20 example, and not limitation, FIG. 1 illustrates operating system 134, application programs 135, other program modules 136 and program data 137.

The computer 110 may also include other removable/non-removable, volatile/nonvolatile computer storage media. By way 25 of example only, FIG. 1 illustrates a hard disk drive 140 that

reads from or writes to non-removable, nonvolatile magnetic media, a magnetic disk drive 151 that reads from or writes to a removable, nonvolatile magnetic disk 152, and an optical disk drive 155 that reads from or writes to a removable, nonvolatile

5 optical disk 156 such as a CD ROM or other optical media.

Other removable/non-removable, volatile/nonvolatile computer storage media that can be used in the exemplary operating environment include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital

10 video tape, solid state RAM, solid state ROM, and the like.

The hard disk drive 141 is typically connected to the system bus 121 through a non-removable memory interface such as interface 140, and magnetic disk drive 151 and optical disk drive 155 are typically connected to the system bus 121 by a

15 removable memory interface, such as interface 150.

The drives and their associated computer storage media, discussed above and illustrated in FIG. 1, provide storage of computer-readable instructions, data structures, program modules and other data for the computer 110. In FIG. 1, for

20 example, hard disk drive 141 is illustrated as storing

operating system 144, application programs 145, other program modules 146 and program data 147. Note that these components can either be the same as or different from operating system 134, application programs 135, other program modules 136, and

25 program data 137. Operating system 144, application programs

145, other program modules 146, and program data 147 are given  
different numbers herein to illustrate that, at a minimum, they  
are different copies. A user may enter commands and  
information into the computer 20 through input devices such as  
5 a keyboard 162 and pointing device 161, commonly referred to as  
a mouse, trackball or touch pad. Other input devices (not  
shown) may include a microphone, joystick, game pad, satellite  
dish, scanner, or the like. These and other input devices are  
often connected to the processing unit 120 through a user input  
10 interface 160 that is coupled to the system bus, but may be  
connected by other interface and bus structures, such as a  
parallel port, game port or a universal serial bus (USB). A  
monitor 191 or other type of display device is also connected  
to the system bus 121 via an interface, such as a video  
15 interface 190. In addition to the monitor, computers may also  
include other peripheral output devices such as speakers 197  
and printer 196, which may be connected through a output  
peripheral interface 190.

The computer 110 may operate in a networked environment  
20 using logical connections to one or more remote computers, such  
as a remote computer 180. The remote computer 180 may be a  
personal computer, a server, a router, a network PC, a peer  
device or other common network node, and typically includes  
many or all of the elements described above relative to the  
25 computer 110, although only a memory storage device 181 has

been illustrated in FIG. 1. The logical connections depicted in FIG. 1 include a local area network (LAN) 171 and a wide area network (WAN) 173, but may also include other networks. Such networking environments are commonplace in offices, 5 enterprise-wide computer networks, intranets and the Internet. When used in a LAN networking environment, the computer 110 is connected to the LAN 171 through a network interface or adapter 170. When used in a WAN networking environment, the computer 110 typically includes a modem 172 or other means for 10 establishing communications over the WAN 173, such as the Internet. The modem 172, which may be internal or external, may be connected to the system bus 121 via the user input interface 160 or other appropriate mechanism. In a networked environment, program modules depicted relative to the computer 15 110, or portions thereof, may be stored in the remote memory storage device. By way of example, and not limitation, FIG. 1 illustrates remote application programs 185 as residing on memory device 181. It will be appreciated that the network connections shown are exemplary and other means of establishing 20 a communications link between the computers may be used.

#### ISOLATING AND BINDING ASSEMBLY VERSIONS

The present invention is generally directed to isolating versions of components (including code and/or data) per- 25 application program or the like, in a manner that allows

multiple versions of the same component to exist and operate side-by-side on a system. For practical purposes, components may be collected into an assembly, which, when referring to items such as a component, is the lowest unit of storage

5 packaged for activation, distribution and versioning, and isolation, as described herein. Rather than deal with individual components, of which there may be a relatively large number, many of the actions regarding components that are grouped together can be handled by referring to their assembly.

10 For example, rather than list in the manifest 204<sub>1</sub> the dependencies on a large number of individual components that are packaged together in an assembly, the manifest may simply list a dependency on the assembly. As used herein, the term "assembly" will refer to one or more components, whether

15 referring to a single component (e.g., one contiguous DLL) or to a plurality of components grouped together.

Assemblies can be shared, such as when more than one application or the like needs an instance of the assembly's code. To provide significant flexibility while being

20 transparent to existing and newly-developed applications, the present invention has been implemented in an operating system, with applications being run via the operating system. As will be understood, however, the present invention is not limited to applications and/or an operating system implementation, but

25 rather is capable of being implemented by virtually any

mechanism internal or external to executable code (e.g., an application) that needs or wants to use a specific version of an assembly. Note that as used herein, an application program is not limited to any particular type of software product, but

5 includes any executable code such as operating system components, drivers and so on that in turn use other assemblies. Notwithstanding, the present invention will be primarily described with an application that uses assemblies including DLLs, resources and objects.

10 FIG. 2 shows application programs (Application<sub>1</sub>-Application<sub>m</sub>) 200<sub>1</sub>-200<sub>m</sub> maintained, for example, in the non-volatile storage (e.g., hard disk drive 141) of the computer system 100 (FIG. 1). To identify specific versions of one or all of the specific assemblies the application prefers to use,

15 an application such as the application<sub>1</sub> 200<sub>1</sub> in folder 202 of FIG. 2 is associated with (or includes) an application manifest 204<sub>1</sub>, typically named with the same name as the application executable but with a different file extension. In general, an application manifest is an XML (eXtensible Markup Language) 20 formatted file or other suitable file that comprises metadata (e.g., 206<sub>1</sub>) describing an application's dependencies on shareable assembly versions, (sometimes referred to as side-by-side assemblies), and also includes metadata to describe any assemblies private to the application. The application

25 manifest may be separate from the application or may be

compiled into the application's binary code / data, as long as it can be easily accessed. Note that other applications 202<sub>1</sub>-202<sub>m</sub> (typically in different folders) may or may not have application manifests associated therewith.

5        Although the application manifest lists its dependencies on assembly versions, it should be noted that technically, the application is only dependent on the manifest-specified assemblies themselves, not necessarily the exact versions that are specified. Instead, the specified versions are only those 10 which have been tested with the application. In one implementation, another version of a needed assembly can replace the application-preferred version when additional information is available to the assembly loading mechanism (e.g., an operating system component). For example, as also 15 described in copending United States Patent Application entitled "*Configurations for Binding Software Assemblies to Applications*" assigned to the assignee of the present application, filed concurrently herewith, and hereby incorporated by reference, policy data (configurations) and/or 20 an assembly manifest associated with the specified assembly may override the version information set forth in the application manifest. Nevertheless, it is expected that such policies and assembly manifests will be used conservatively, e.g., only for important fixes and/or after thorough testing, since they will 25 cause replacement of the trusted assembly version.

Two types of assemblies are possible, those having strong names, e.g., including a public key signature or the like such that any two different assemblies can be unambiguously identified, and those having a simple name, which may be

5 ambiguous in the context of an application and, for example, do not contain a public key. To provide isolation, any simply-named assemblies on which an application manifest specifies a dependency are treated as privatized assemblies 210 of FIG. 2A, (wherein the dashed box represents that the privatized

10 assemblies may or may not be present for a given application).

Privatized assemblies are those that the application does not intend to be shared with other applications. Privatized assemblies that have simple names are normally installed into the same folder as the executable application code, whereby the

15 assembly is isolated and the application is given the effect of being monolithic, e.g., its assemblies are not influenced by different assemblies having the same simple name, and so forth.

By not being shared, privatized assemblies with simple names thus have the benefit of virtually complete isolation, at the

20 expense of the benefits obtained by sharing. Assemblies having strong names do not need to be placed into the application

folder for isolation purposes, because assemblies with strong names are known to be the exact one the application needs.

Thus, instead of being privatized by storing in a certain

25 directory, such assemblies may be placed into a global assembly

cache 212 to obtain the benefits of sharing, while effectively preserving isolation, because an application that asks for a strongly named assembly will get a copy that is exact.

Note that as represented in FIG. 2, the assembly cache 208 5 appears as a distinct container, however it may be a logical container, and does not have to correspond to a common folder or the like in the file system. For example, the assembly cache may comprise multiple folders to improve performance.

Moreover, as long as the operating system maintains some map as 10 to their actual location, the assemblies may be distributed

among various folders of the file system, or even other file system volumes, on the same or other machines. For example, a given assembly may be maintained on a network file server.

Indeed, it should be noted that any of the software files /

15 data structures described herein may be remotely maintained and downloaded. Notwithstanding, maintaining the assembly cache in a set of one or more folders has advantages, including that a dedicated set of folders can be accessed-controlled in an efficient manner, a scattered assembly cache would have to

20 track folder movement and so on. In any event, the assembly cache will be considered herein as a single container (e.g., comprising one or more folders) accessible by the operating system when an assembly is needed.

As further represented in FIG. 2, the application 25 executables, application manifest 204<sub>1</sub> and assemblies 210<sub>1</sub>-210<sub>n</sub>

are maintained (e.g., as files) in non-volatile storage 141.

More particularly, in one implementation, when the application 200<sub>1</sub> is installed onto a computer system, the application

manifest 204<sub>1</sub> is copied to the application's folder (the same

5 one that contains the application executable file), while the strongly-named assembly files (e.g., 210<sub>1</sub> and 210<sub>2a</sub>) are copied

to the side-by-side assembly cache 208. Note that to provide side-by-side existence of assembly versions, any existing

assembly versions are not overwritten in the assembly cache 208

10 when another version is installed, (although a version can be removed by other means, at the risk of breaking an application

that depends on that version). The assembly cache can be

hidden and/or access controlled to prevent assemblies from

being easily removed.

15 Privatized assemblies that are not strongly named are

copied to the application folder, as described above. To this end, an installer or the like contacts the operating system,

which then directs the installer as to where (e.g., what

folder) to install any given application files or assembly

20 files based on the manifest type, file name data (strong or simple), and/or other installation information. In this

manner, any privatized assemblies with simple names are

installed into the same folder as the executable application

code, as described above, while sharable assemblies are stored

25 in the assembly cache 208.

The assembly manifest is preferably copied to the assembly cache 208 with its corresponding assembly at the time of installation. The assembly manifest describes the assembly and includes information about its individual assembly, including, 5 for example, the name and version of the assembly, the items (program files, resources) that make up the assembly, and the binding path to items within the assembly (e.g., for Win32 DLLs this is the location of the DLL relative to the root of the assembly, whereas for COM Servers this is the CLSID (class 10 identifier), ProgID (programmatic identifier) and other COM metadata). The assembly manifest may also include any dependencies on other assemblies, object classes and global names.

Example manifests in XML format are set forth in the 15 tables below, wherein TABLE1 is an example of a simple application manifest where the application depends on a side-by-side version of COMCTL32:

**TABLE1**

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<assembly xmlns="urn:schemas-microsoft-com:asm.v1"
manifestVersion="1.0">
<assemblyIdentity
    version="1.0.0.0"
    processorArchitecture="X86"
    name="Microsoft.Windows.mysampleApp"
    type="win32"
/>
<description>Your app description here</description>
<dependency>
    <dependentAssembly>
        <assemblyIdentity
            type="win32"
```

```
name="Microsoft.Windows.Common-Controls"
version="6.0.0.0"
processorArchitecture="X86"
publicKeyToken="6595b64144ccf1df"
language="*"
/>
</dependentAssembly>
</dependency>
</assembly>
```

TABLE2 is an example of an application manifest where the application depends on a side-by-side version of COMCTL32 and an assembly is privatized to the application:

TABLE2

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<assembly xmlns="urn:schemas-microsoft-com:asm.v1"
manifestVersion="1.0">
<assemblyIdentity
    version="1.0.0.0"
    processorArchitecture="X86"
    name="Microsoft.Windows.mysampleApp"
    type="win32"
/>
<description>Your app description here</description>
<dependency>
    <dependentAssembly>
        <assemblyIdentity
            type="win32"
            name="Microsoft.Windows.Common-Controls"
            version="6.0.0.0"
            processorArchitecture="X86"
            publicKeyToken="6595b64144ccf1df"
            language="*"
        />
    </dependentAssembly>
</dependency>
<!-- Privatized assembly -->
<file name="mypaint.dll">
    <comClass description="Font Property Page"
    clsid="{0BE35200-8F91-11CE-9DE3-00AA004BB851}"/>
        <comClass description="Color Property Page"
    clsid="{0BE35201-8F91-11CE-9DE3-00AA004BB851}"/>
            <comClass description="Picture Property Page"
    clsid="{0BE35202-8F91-11CE-9DE3-00AA004BB851}"/>
    </file>
    <file name="mydraw.dll"/>
    <file name="testctl32.dll">
        <windowClass>ToolbarWindow32</windowClass>
        <windowClass>ComboBoxEx32</windowClass>
        <windowClass>testctl32_trackbar32</windowClass>
        <windowClass>testctl32_updown32</windowClass>
        <windowClass>testctl32_progress32</windowClass>
    </file>
    <file
        name="new\SxS_COM.dll">
        <comClass
            description="SxSTestObject Class"
            clsid="{F3B09421-5A10-4756-98AF-7A447E07D3C2}"
            threadingModel="Apartment"

```

```
    tlbid="{B21101B9-90DF-4841-BEAC-41F68CD94BDC}"  
  
    progid="SxS_COM.SxS_COMObject.1">  
      <progid>"SxS_COM.SxS_COMObject"</progid>  
      </comClass>  
    <interface  
      iid="{D8C178A3-F275-4EAB-B6F4-896B5B9A0FC0}"  
      name="ISxSTestObject"  
      proxystubclsid="{00020424-0000-0000-C000-  
00000000046}"  
      proxystubclsid32="{00020424-0000-0000-C000-  
00000000046}"  
      tlbid="{B21101B9-90DF-4841-BEAC-41F68CD94BDC}"/>  
    <typelib  
      tlbid="{B21101B9-90DF-4841-BEAC-41F68CD94BDC}"  
  
      version="1.0"  
      description="SxS_COM 1.0 Type Library"  
      helpdir="new"/>  
    </file>  
</assembly>
```

Assemblies may be dependent on other assemblies, which in turn are dependent on other assemblies, and so on. To ensure the proper versions of dependent assemblies, one or more of the 5 assemblies 210<sub>1</sub>-210<sub>n</sub> (e.g., assembly 210<sub>1</sub>) may have an assembly manifest 212<sub>1</sub> associated therewith that provides assembly dependency data 214<sub>1</sub>. To this end, assembly authors that create side-by-side assemblies may also author an assembly manifest 212<sub>1</sub> with each assembly, and have that assembly 10 manifest evaluated for proper version dependencies. Note that although not separately shown in FIG. 2, it is understood that each other assembly in the assembly cache 208 may have an assembly manifest associated therewith.

A sample assembly manifest is set forth in TABLE3 below:

TABLE3

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<assembly xmlns="urn:schemas-microsoft-com:asm.v1"
manifestVersion="1.0">
    <assemblyIdentity type="win32"
name="Microsoft.Tools.VisualCPlusPlus.Runtime-Libraries"
version="6.0.0.0" processorArchitecture="x86"
publicKeyToken="6595b64144ccf1df"/>
    <file name="mfc42u.dll"
hash="3eab067f82504bf271ed38112a4ccdf46094eb5a"
hashalg="SHA1">
        <comClass description="Font Property Page"
clsid="{0BE35200-8F91-11CE-9DE3-00AA004BB851}"/>
        <comClass description="Color Property Page"
clsid="{0BE35201-8F91-11CE-9DE3-00AA004BB851}"/>
        <comClass description="Picture Property Page"
clsid="{0BE35202-8F91-11CE-9DE3-00AA004BB851}"/>
    </file>
    <file name="mfc42.dll"
hash="ac72753e5bb20446d88a48c8f0aaae769a962338"
hashalg="SHA1"/>
    <file name="atl.dll"
hash="a7312a1f6cfb46433001e0540458de60adcd5ec5"
hashalg="SHA1">
        <comClass description="Registrar Class"
clsid="{44EC053A-400F-11D0-9DCD-00A0C90391D3}"
progid="ATL.Registrar"/>
        <interface iid="{B6EA2051-048A-11D1-82B9-
00C04FB9942E}" name="IAxWinAmbientDispatch"
proxyStubClsId32="{00020424-0000-0000-C000-000000000046}"/>
        <typelib tlibid="{44EC0535-400F-11D0-9DCD-
00A0C90391D3}" version="1.0" helpdir="" />
    </file>
    <file name="msvcrt.dll"
hash="ba62960ceb15073d2598379307aad84f3a73dfcb"
hashalg="SHA1"/>
    <file name="msvcirt.dll"
hash="84eb92153ff379c67c2727cc7f6931e011ff8121"
hashalg="SHA1"/>
    <file name="msvcp60.dll"
hash="96952787a1676e38107ab93c6a33b9bcd1c912e"
hashalg="SHA1"/>
</assembly>
```

Among other things, an assembly manifest can specify (e.g., in an XML format) an assembly's dependency on a particular version of an assembly. For example, in FIG. 2, the assembly manifest 212<sub>1</sub> includes metadata that will instruct the 5 operating system that assembly<sub>1</sub> version 4.2.2.1 has a dependency on assembly<sub>n</sub> version x.x.x.x. In addition to dependency information, an assembly manifest can contain an instruction that overrides application manifest version information, such as to specify that one version of an assembly 10 should be used instead of another. For example, in FIG. 2, the assembly manifest 212<sub>2a</sub> associated with the assembly 210<sub>2a</sub> includes metadata instructing the operating system to substitute version 6.0.0.4, i.e., the assembly 210<sub>2b</sub>, whenever there is a request to use version 6.0.0.3 (the assembly 210<sub>2a</sub>). 15 In this manner, an assembly author may override the version specified by an application manifest, or, like an application, may specify a dependency on a given assembly version.

Note that although not shown in FIG. 2, a later-installed application policy can also change an application manifest's 20 requested assembly version such that the existing manifest does not have to be replaced or have its contents modified to allow an application to effectively change what is in its original (e.g., shipped and installed with the application code) manifest. In other words, via the application policy, the 25 original manifest does not have to be reinstalled or modified

to change a dependency. The application policy settings can also bypass an assembly manifest's version overrides, and a system policy can override any other versioning metadata. In this manner, a flexible architecture is provided in which

5 application authors and assembly authors, as well as system administrators, may create safe, isolated applications by simply creating declarative manifests or policies that control the dependencies on shared assemblies, while enabling changes to dependencies to be made when necessary. These and

10 additional aspects of the architecture, including methods for resolving which version will be loaded when the various manifests and policies provide different instructions, are further described in the aforementioned United States Patent Application entitled "*Configurations for Binding Software*

15 *Assemblies to Applications.*"

In accordance with one aspect of the present invention, the metadata in an application manifest and the metadata in appropriate assembly manifests is used during the creation of an activation context for the application to provide an

20 efficient way to load the correct version of an assembly for the corresponding application. As a result, when an application uses the side-by-side assemblies, the application code does not have to change internally to reflect the version of the assembly being used, e.g., the application simply

25 executes its code generally rather than perform different

operations each tailored to a particular assembly version. For example, in FIG. 2, for application 200<sub>1</sub>, the metadata 206<sub>1</sub> of the application manifest 204<sub>1</sub> and the metadata 214<sub>1</sub> and 214<sub>2a</sub> in assembly manifests 212<sub>1</sub> and 212<sub>2a</sub>, respectively, is analyzed and 5 used to load the correct assembly versions. Note that manifest metadata need not specify an exact version, but may alternatively specify a range of acceptable versions.

As represented in FIG. 3, when one (or more) of a set of activation APIs (application programming interfaces) 300 are 10 called in response to a request to run an application program, the activation APIs 300 cause a persistable activation context 302 for that program to be constructed if a valid one does not already exist for the application, (for example, when the application is being run for the first time or the activation 15 context 302 exists but its information is invalid). To construct the activation context 302, the activation APIs call (or otherwise include) an initialization mechanism 304, wherein the call is generally represented in FIG. 3 by the arrow accompanied by the circled numeral one (1). If a new 20 activation context 302 needs to be constructed, the initialization mechanism 304 reads and interprets the application manifest 204<sub>1</sub> as represented in FIG. 2 by the arrows labeled with circled numerals two (2) and three (3). The initialization mechanism 304 also reads (circled numerals 25 four (4) through seven (7)) and interprets the assembly

manifests 212<sub>1</sub> and 212<sub>2a</sub> to obtain any dependency / override information therein. Although not separately shown in FIG. 3, if the assembly manifests specify dependencies on other assemblies, the assembly manifests of those other assemblies 5 are read, and so on, until there are no remaining dependencies to handle. In general, the initialization mechanism 304 essentially constructs a dependency graph or other list that comprises a full set of assemblies that the application and its dependent assemblies, and their dependent assemblies, and so 10 on, will need, and with the completed dependency graph, constructs the activation context 302 (the arrow labeled with circled numeral eight (8)). In general, there is an activation context 302 for each application that has an expressed assembly dependency, and each activation context includes a mapping 15 table preferably hashed for quick lookup.

It should be noted that not every assembly used by an application needs to be specified in the application manifest, nor does each assembly manifest have to specify all of its dependent assembly versions, only those versions wherein there 20 is a particular version desired. This is because the architecture described herein allows a default assembly version to be used when a particular version of an assembly is not specified in a manifest. Normally, when more than one version of an assembly is available, the default assembly is the most- 25 recent version, however it is possible for an administrator or

user to set (e.g., via interaction with the operating system through a dialog box, property sheet or the like) any version as a default.

In keeping with the present invention, the activation context 302 for an application maps version-independent assemblies that are requested by an application to the versions that are specified in the application manifest and/or assembly manifests. By way of example, FIG. 4 represents some of the information that may be maintained in an activation context, e.g., an activation context 302<sub>1</sub> constructed for the application 200<sub>1</sub>. In FIG. 4, the activation context 302<sub>1</sub> includes a table of contents 400 (e.g., providing offsets to its recordsets) for rapid access to the data therein.

Once created, the activation context 302<sub>1</sub> is maintained in a persistable binary form for caching. Preferably, a new activation context is recomputed each time the application is launched, and freed when the application is closed. However, in one alternative, the activation context may be preserved, e.g., to a non-volatile storage. If preserved, because policy or the like may change the dependency information therein, (e.g., a new assembly manifest has been installed), the activation context 302<sub>1</sub> may include a cache coherency section 402 that is used to detect whether the saved activation context 302<sub>1</sub> is valid, wherein when the activation context 302<sub>1</sub> is not

coherent with current policy, it is recomputed. A section per API that implements version-specific binding is maintained.

To map the application's requests to the proper assembly versions, the activation context 302<sub>1</sub> includes a DLL redirector 5 section 404 and an object class redirector section 406. The DLL redirector section 404 includes a record or the like for each DLL dependency that includes fields (e.g., 408<sub>1</sub> and 409<sub>1</sub>) that relate the DLL name used by an application to the exact pathname of the version specified in the application manifest 10 and/or assembly manifest. The object class redirector section 406 includes a record or the like for each object class (e.g., Windows® object class) on which an application depends, wherein each record includes fields (e.g., 412<sub>1</sub>, 413<sub>1</sub> and 414<sub>1</sub>) that relate the object class name used by an application to the DLL 15 file it is in and a version specific name. Note that the fields are arranged in a manner that optimizes lookup, e.g., the application-provided request data corresponds to the search key, and the records may be arranged in any way (e.g., 20 alphabetically, by frequency, linearly, binary or so on) to speed searches.

Via the activation context, during runtime, an application's requests for assemblies can be efficiently satisfied with the correct version of that assembly. If a given assembly is not found in the activation context data, the 25 default assembly is used. To summarize, when an application

first runs, the activation context built from the manifest data is cached, whereby the global, version-independent named objects requested by an application are mapped to version-dependent named objects as specified in the manifest. As the 5 application executes and requests a named object via one of the activation APIs, the version-independent named objects are applied in a version specific fashion by accessing the application context, whereby the application gets the correct version.

10 FIG. 5 represents the general operation during runtime, wherein an application 202<sub>1</sub> requests via one of a set of application APIs (e.g., 300<sub>1</sub>) a version-independent assembly (represented via the arrow labeled with circled numeral one (1)). Application APIS include those directed to loading DLLs, 15 COM server loading, COM interface proxy stub metadata, type libraries for COM, program identifiers for COM, object (e.g., Windows<sup>®</sup>) classes, kernel global objects (e.g., semaphores, mutexes, events, shared memory, COM categories), application settings and database or registry connections.

20 When the application API 300<sub>1</sub> receive the request, the request data (e.g., the application provided name) is passed to a runtime version-matching mechanism 502 (the arrow labeled two (2)). The runtime version-matching mechanism 502 locates the correct activation context 304<sub>1</sub> for the calling application 25 202<sub>1</sub>, and accesses the records therein to determine the correct

version of the requested assembly (the arrows labeled three (3) and four (4)). Via the tables in the activation context 304<sub>1</sub>, the runtime version-matching mechanism 502 will either return (e.g., as a return parameter, with the arrow labeled five (5))

5 the path and filename of the version-specific assembly, or a not-found status or the like (and/or the path and filename of the default file) to the activation API that called it, in which case the activation API will load the default assembly.

As represented in FIG. 5 by the arrows labeled six (6) through 10 eight (8), the activation API 300<sub>1</sub> accesses the assembly cache

208 to load the correct version of the assembly. Note that alternatively, the runtime version-matching mechanism 502 may access the assembly cache 208 on behalf of the API to obtain and/or load the correct version, which is either the one listed 15 in the records or the default version if none was found. In any event, the correct assembly version 510 is loaded and the activation API 300<sub>1</sub> returns from the call to the application 202<sub>1</sub>, (the arrow labeled nine (9)), and the application can use 20 the loaded assembly 510 (the arrow labeled ten (10)).

20 Turning to an explanation of the operation of the present invention with particular reference to the flow diagrams of FIGS. 6, 7 and 9, as described above, the mapping of an application to a specified version of an assembly or other data structure essentially comprises two phases, an initialization 25 phase (FIGS. 6 and 7) and a runtime phase (FIG. 9). In

general, the initialization phase constructs the activation context, if needed, that maps version-independent assemblies to version-specific assemblies based on the dependencies (and other instructions) in the various manifests. Then, during a 5 runtime phase, (FIG. 9), the activation context is accessed as needed to rapidly locate and load the appropriate versions when an application requests an assembly that it needs. Note that although it is feasible to eliminate the initialization phase by walking the various manifest data to locate the correct 10 version on each request, such requests are frequently made during an application's runtime, and it is thus more efficient to construct the context once and thereafter access it on each request.

FIG. 6 represents exemplary steps that may be taken during 15 initialization (pre-application execution) phase to construct the activation context, if needed. When creating a new process, the initialization mechanism 304 (e.g., of the operating system) checks for an application manifest in same file system directory as the calling executable, as represented 20 in FIG. 6 by step 600. If an application manifest does not exist, the initialization mechanism 304 handles its absence in another manner, (step 602), e.g., it can search for it, and/or the operating system essentially will give the application default versions during runtime, such as by first loading any 25 requested assembly from the application's own directory when

one is present, and otherwise using the default assemblies from the assembly cache.

When step 600 determines that an application manifest exists, the initialization mechanism 304 (FIG. 3) preferably

5 branches to step 610 to create the activation tables.

Alternatively, if activation contexts may be preserved rather than recomputed each runtime, the initialization mechanism 304 may check for an existing activation context (e.g., 302) for the application. If an existing activation context is found,

10 step 604 branches to step 606 to validate it, otherwise step

604 branches to step 610. Step 606 checks the activation

context to determine if it is coherent with current

configuration, and if so, the existing activation context 302 can be used (step 608) and the initialization process ends. If

15 alternatively the activation context 302 is not coherent with current configuration at step 606, for example, because a more recent configuration has been provided to the system, the initialization process continues to step 610 to recompute a new activation context 302.

20 In the event that the initialization process continues to step 610 to create the activation context, step 610 represents obtaining the binding information from the application manifest. Steps 610, 612, 614 and 616 of FIG. 6 are executed, along with the steps of FIG. 7, essentially to walk through the 25 various manifests in order to build up a dependency graph,

replacing assembly information (nodes) as necessary in the dependency graph and adding any new nodes to include the dependencies of any assembly manifests.

By way of example, FIGS. 7 operates once the application manifest has its dependent assemblies added to the dependency graph (step 610 of FIG. 6) and an assembly (node) therein has been selected (step 612, e.g., via a top-down, left-to-right or other suitable progression). At step 700 if a selected assembly in the graph has an assembly manifest, step 700 branches to step 702, otherwise there are no dependencies or replacements to deal with for this assembly, and the process returns to FIG. 6 to handle any assemblies that have not been handled. If there is an assembly manifest, step 702 tests whether the assembly manifest includes data specifying that the assembly should be replaced with another version. If so, the new version replaces it in the dependency graph, and the process returns to step 700 to evaluate that version's assembly manifest, (if any). For example, in FIGS. 2 and 8, (wherein FIG. 8 shows a dependency graph 800 corresponding to the assemblies identified in FIG. 2), the assembly<sub>2</sub> version 6.0.0.2 is replaced by the assembly manifest with version 6.0.0.3. This in turn may have an assembly manifest that causes its replacement, and so on, until an assembly manifest is found that does not specify a further replacement.

When the appropriate assembly is in the graph following any possible replacements, step 702 branches to step 706 wherein any dependencies listed in the current assembly's manifest are added to the dependency graph. For example, in 5 FIGS. 2 and 8, the assembly<sub>1</sub> has a dependency on the assembly<sub>n</sub>, whereby assembly<sub>n</sub>'s information is added to the graph 800. In this manner, the correct assembly versions of those specified in the manifests will wind up in the dependency graph. Note that although not shown in FIG. 7, only dependent assemblies 10 not already listed in the graph will have new nodes added therefor, so that each assembly is only selected and handled once, e.g., a pointer can go in the graph to an existing dependency rather than add a new node, thereby eliminating circular dependencies. The process continues to step 708 to 15 mark the selected assembly as having been handled, before returning to FIG. 6 to select another assembly for handling, until none remain. When the assemblies have been handled at step 614, the dependency graph is used to construct the activation context at step 618, essentially by filling in the 20 fields with the correct version information for each assembly present in the graph. Note that a simple list can be used instead of a graph, however a graph provides information about the relationships between assemblies as well as which ones are used, which can be used to construct a more efficient 25 activation context. When constructed, the activation context

is copied to the child process in the operating system data structure's defined environment process, making it the process default.

FIG. 9 shows the general steps taken to locate and load the correct version at runtime, e.g., when a program at runtime creates a global object, the system automatically gives it a version-specific named object by consulting the activation context built from the manifest. Note that FIG. 9 is intentionally streamlined for efficiency, i.e., the activation context is built in advance, so that during runtime an efficient and rapid lookup can be performed to find the appropriate version.

Beginning at step 900 the activation API receives the application request including the version-independent assembly name, not the version specific name, and passes it as a parameter or the like to the runtime version matching mechanism, where it is received at step 902. If an entry for the name is in the activation context at step 904, the runtime version matching mechanism returns the version specific information (e.g., including the path and filename of the correct version) based on the manifest at step 906. If an entry for the name is not found in the activation context at step 904, at step 908 the runtime version matching mechanism returns a not found status, (or alternatively can determine and 25 return the path and filename of the default version). At step

910, the activation API loads appropriate version, and returns  
a loading status or the like. The operating system also maps  
any uses of this named object to the appropriate version to  
allow for multiple versions of the code module to run  
5 simultaneously without interfering with each other, whereby,  
for example COM object data is isolated per object. At this  
time, the correct version as specified in the manifests is  
loaded, even though the application's executable code did not  
specify any version. Indeed, by providing an associated  
10 manifest that can be stored into the application's directory,  
an already existing application (e.g., written and installed  
before the present invention) can benefit from the present  
invention.

By way of a further example, consider two versions of an  
15 object class container, COMCTL32 version six (v6), and COMCTL32  
version seven (v7), both of which have a SysListView object  
class therein. When the application launches for the first  
time, the operating system reads the manifest and creates  
version-specific classes for items listed in the manifest, for  
20 example, the application manifest has listed v6 and this has  
not been overridden. The activation context is created and the  
object class created for SysListView, wherein the version  
number for the COMCTL32 object class container and the  
SysListView object class is v6, as specified in the application  
25 manifest.

When the application program is running and requests an object class, the application does so as it always has, that is, by specifying the object, SysListView, without specifying any version information. However, based on the activation 5 context, the appropriate version name of SysListView (in this example corresponding to V6) will be automatically returned and version v6 of the object will be located. As is understood, the application developer need not modify the application in any way to get the appropriate version, but instead only needs 10 to provide a suitable application manifest.

In this manner, instead of having a system default of a single control such as SysListView in COMCTL32 that the processes use, multiple side-by-side versions of SysListView can be available and running. Each process has the option to 15 choose the specific version to use. Moreover, because more metadata is being maintained about the runtime, self-healing systems are possible. For example, if an application fails, the operating system may intelligently use this metadata to repair the problem.

20 As can be seen from the foregoing detailed description, there is provided a method, system and infrastructure to version globally named objects in the system. Application authors may create safe, isolated applications by simply creating a declarative manifest that describes dependencies on 25 these shared objects, without needing to be concerned with

coding the application to adjust to the version of the assembly being used. By the present invention, assemblies can be safely shared and applications can be more completely isolated.

While the invention is susceptible to various 5 modifications and alternative constructions, certain illustrated embodiments thereof are shown in the drawings and have been described above in detail. It should be understood, however, that there is no intention to limit the invention to the specific form or forms disclosed, but on the contrary, the 10 intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention.

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